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Ureteral Reflux and Residual Volumes—Minimizing Irradiation

VESICOURETERAL REFLUX IN CHILDHOOD has been clearly implicated as a cause of significant injury to the kidney. Reflux nephropathy is a complex issue and concerns both renal infection and direct renal injury caused by penetration of urine into the renal pyramid. Traditionally, children presenting with a urinary tract infection have been evaluated by intravenous urography and contrast cystography. Present methods of evaluation in many centers consist of an ultrasonogram of the kidneys with a radionuclide cystogram in female patients but a conventional contrast cystourethrogram in male patients. In either sex, cystography is done at about seven to ten days following antibiotic therapy, as it is likely that during the acute phase of an infectious process there may be sufficient bladder wall edema to prevent detection of clinically significant reflux.

Regardless of the method of initial evaluation, the radionuclide cystogram is the method of choice for sequential evaluation. The technique has been well described and it is simple to do. A small feeding catheter is aseptically inserted into the urinary bladder via the urethra. About 100 ml of sterile 0.1 normal saline is instilled into the bladder. A 250-μCi dose of technetium Tc 99m sulfur colloid is administered via intravenous tubing. The patient's bladder is then slowly filled to the point of spontaneous voiding. Continuous posterior renal scintiphotos and computer data that include the dome of the urinary bladder are obtained sequentially. A technique for indirect radionuclide cystography has been described; although it may be more physiologic, most observers feel that there is a substantial risk of missing clinically significant reflux using this method.

Following voiding, the residual urinary tract volume may be calculated. This is a simple measurement based on prevoiding and postvoiding urinary tract counts and the volume of urine voided. The amount of residual bladder volume has much less consequence than that retained in the entire collecting system, which should be determined when one calculates these values.

Although difficult to document, many observers feel that the radionuclide cystogram is more sensitive for detecting clinically significant reflux than the conventional contrast cystogram. This relates to the continuous monitoring and the greater ease of detection of small amounts of complete (to the level of the renal pelvis) reflux. The single most consequential aspect of the difference between radiographic contrast and radionuclide cystography is the radiation dose. A typical 30-minute radionuclide cystogram delivers about 30 mrads to the bladder wall, less than 5 mrads to the male gonads and about 2 to 3 mrads to the ovaries. These figures represent about 1/100th of the radiation-delivered dose from a well-done radiographic contrast cystogram.

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Bone Scintigraphy—No Diagnostic Equal

DESPITE MAJOR ADVANCES in computed tomography and nuclear magnetic resonance, bone scintigraphy remains the most sensitive and the most practical whole-body screening procedure for skeletal involvement with malignancy. For proper cost-effectiveness, however, bone scanning should be used routinely only to evaluate those malignant disorders with a substantial likelihood of skeletal dissemination. With the probability of bone scan positivity at diagnosis indicated in parentheses, these tumors include stages III and IV rhabdomyosarcoma (56%), neuroblastoma (51%), prostatic carcinoma (31.8%), Hodgkin's disease (27%), stage III breast carcinoma (22.5%) and all other lymphomas (14%). Cancers not warranting routine bone scintigraphy at diagnosis include bladder carcinoma (5% to 15%), cervical carcinoma (0% to 10%), asymptomatic bronchogenic carcinoma (6% to 8%), ovarian carcinoma (0% to 8%), uterine carcinoma (0% to 4%), head and neck cancer (1%) and stages I and II malignant melanoma (0% to 1%). In stages I and II breast carcinoma (2% to 6%), annual bone scans are appropriate to follow the disease because of the high probability of skeletal involvement at recurrence (7% to 58%).

Although 37% of bone scans are positive at diagnosis in patients with multiple myeloma, skeletal radiography is clearly superior in sensitivity. In all patients with malignancy, bone scintigraphy is appropriate to evaluate musculoskeletal pain or an elevated serum alkaline phosphatase level. In primary bone cancer, the bone scan can effectively show the extent of the primary lesion, spread to distal skeletal sites (11% to 45%) and calcified soft tissue metastases.

Among benign skeletal processes, the bone scan is useful to evaluate symptomatic osteoid osteoma (including surgical location), fibrous dysplasia, brown tumors and aneurysmal bone cysts. Its high sensitivity for acute osteomyelitis in adults (90% to 95%) can be equaled in children by the use of the three-phase bone scan. Combined with gallium 67 or indium 111-granulocyte scintigraphy, it is effective in assessing chronic osteomyelitis and in differentiating loosening from infection in joint prostheses. Subradiographic fractures, especially stress fractures, are best identified by bone scintigraphy. Paget's disease produces intensely positive labeling on a bone scan, so that bone scintigraphy is useful in evaluating the extent of pagetic skeletal involvement, including monostotic versus polyostotic Paget's disease and, to a lesser extent, in monitoring response to therapy or progression of disease. Temporomandibular joint disease is detected with 94% sensitivity by single photon emission computed tomography. The evolution of avascular necrosis (and other types of bone infarction) is well delineated by serial bone scans. Although the bone scan is abnormal in a large variety of arthritic and degenerative joint conditions, making positive findings highly nonspecific, it can be useful in establishing the presence of early inflammatory joint involvement before radio-

graphic changes, in documenting the number of joints involved in the arthritic process and in ruling out arthritis by showing a normal bone scan. Detectable soft tissue lesions include tissue infarction (myocardial, bowel, rhabdomyolysis), some primary (neuroblastoma, breast, kidney) and secondary (osteogenic sarcoma in lung, carcinoid in liver) tumors and renal or urinary tract pathology (tumors, cysts, obstruction).

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Single-Photon Emission Computed Tomography Bone Imaging—A New Dimension in the Investigation of Back Pain

LOW BACK PAIN is ubiquitous. It is the cause of much suffering and often causes great frustration not only to patients, but to physicians managing such patients. Radiography, including computed tomography (CT), may show no abnormalities or may show structural abnormalities that, in a significant proportion of cases, are resistant to even radical forms of treatment.

Nuclear bone imaging basically shows areas of increased bone metabolism. Conventional planar bone imaging often provides suboptimal information because of its inability to precisely locate abnormal areas in the spine, such as the neural arch, apophyseal joints or adjacent vertebral bodies. Single-photon emission CT (SPECT) is a new, increasingly available technique that adds relatively little cost to routine bone scanning. It has the ability to produce emission CT images ("slices") in multiple planes and thus to increase sensitivity, reduce ambiguities and accurately locate sites of abnormal activity.

Insofar as pain is likely to be directly related to areas of abnormal bone metabolism—that is, due to abnormal stress rather than simply the presence of structural abnormalities—these areas can be localized precisely with SPECT. Such areas of functional abnormality may or may not be associated with the presence or indeed the specific location of structural abnormalities. The etiology of the functional abnormalities and consequent abnormal areas on bone scanning may be associated with tumor, infection, fracture or abnormal local wear and tear. For instance, there is evidence that the presence of spondylolysis, possibly associated with spondylolisthesis, in itself does not always produce symptoms, and that a local area of increased activity on a SPECT scan in the region of a pedicle or facet is a more specific indicator of the origin of the back pain.

The potential to precisely locate the actual cause of back pain has widespread implications. The ability to discern an abnormality in a spine that is essentially normal on an x-ray film or CT scan has significant clinical advantages. Furthermore, the possibility of localizing precisely an area of abnormal bone metabolism associated with structural abnormalities should help decrease the failure rate of some major surgical procedures such as for spondylolisthesis if it can be shown beforehand that the site of abnormal bone activity is not in the region of the spondylolisthesis but rather is related to abnormal wear and tear in an apophyseal joint. This could be easily verified and treated by injection.

In general, the capability to differentiate and precisely locate functional, active disease from solely anatomic changes can aid in the more specific and effective management of patients suffering from back pain.

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Single-Photon Emission Computed Tomography Using Thallium 201 for Evaluating Coronary Artery Disease

PLANAR MYOCARDIAL PERFUSION scintigraphy with thallium 201 is widely used for detecting, localizing and evaluating the extent of myocardial perfusion abnormalities and for differentiating infarcted from ischemic but viable myocardium in patients with possible or known coronary artery disease. With planar ^{201}Tl imaging, however, three-dimensional distribution of radioactivity in the myocardium is represented in a two-dimensional fashion, resulting in overlap of information among various myocardial regions. The planar imaging method, therefore, is not ideally suited to assessing location and overall size of ischemic and infarcted myocardium, the indices that are most predictive of prognosis in coronary artery disease. Single-photon emission computed tomography (SPECT) with ^{201}Tl, using 180° or 360° rotational angular sampling, offers true tomographic studies of myocardial perfusion with reduced overlap of various myocardial regions and improved image contrast. With SPECT, the presence and extent of perfusion defects can be objectively quantified. Several experimental and clinical studies have now shown that ^{201}Tl SPECT can accurately measure the size of ischemic and infarcted myocardium. Thallium 201 SPECT can also accurately detect and locate myocardial perfusion defects in patients with coronary artery disease.

Interpretation of SPECT images requires knowledge of normal regional attenuation patterns and attention to possible artifacts caused by patient motion, breast tissue and inappropriate image reconstruction. SPECT is more difficult to do and interpret than planar ^{201}Tl imaging. Although SPECT is now well validated as an accurate myocardial imaging technique, the degree to which this method will replace the simpler, more widely used and less expensive planar ^{201}Tl approach remains uncertain.

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